

Behaviour of Pile Adjacent to Excavation in Layered Soil

Dr. A.I.Dhatrak¹, S.D.Kulkarni²

¹Associate Professor, Department of Civil engineering, GCOEA Amravati, India

²PG Student, Department of civil engineering, GCOEA Amtavati, India

Abstract— Construction of deep basement structure is common thing in urban cities, as land available for construction is limited. As this excavation carried out near the existing building, the major challenge is to minimize the damage to existing building or underground utilities. As pile foundation were used for high rise building, there is concern with lateral ground movement resulting from soil excavation, may adversely affect the nearby pile foundation. This paper aims at investigating the effect of excavation induced movements on the lateral deflection of pile situated near the excavation in multilayered soil.

Keywords—Deep excavation, Pile, Side supported excavation.

I. INTRODUCTION

In dense urban environments where land is scarce and building are closely spaced, deep excavation for basement construction and other underground facilities like cut cover tunnels are unavoidable. During deep excavation, there is concern that lateral ground movement resulting from the soil excavation, may adversely affect the nearby pile foundation systems.

II. LITRETURE REVIEW

The H.G.Polus L.T.Chen ^[1] represented study of finite element and boundary element method for pile response due to excavation induced moment in clay. C.F.Leung Y.K.Chow and R.F.Sen ^[2] represented a study of centrifuge model tests on instructed deep excavation in dense sand and its influence on an adjacent single pile foundation. A.T.C.Goh, K.S.Wong, C.I.Teh and D.Wen ^[3] presented the result of an actual full scale instrumented study that was carried out to examine the behavior of existing pile due to the nearby excavation activities of tunnel. D.E.L Ong, C.E. Leung and Y.K.Chow ^[4] presents study of series of centrifuge model test to investigate the behavior of pile group of various sizes and configuration behind the retaining wall in very soft clay. Elkady T. ^[5] represented a study of finite element analysis by ABAQUS to assess the effect of excavation depth, distance of pile from side supported excavation, pile stiffness and wall stiffness. Kulkarni. S.R ^[6] presents a study of deep basement

excavation for 33 stored high rises Tower by Finite element software (Plaxis 2D).

From the literature review, it is observed that effect of excavation induced soil movement on adjacent pile (clay and sand) were studied by many researchers. As the soil profile in deep excavation consist of different properties of soil, the study of pile response in layered soil is necessary. There is need to study the effect of deep excavation on adjacent pile considering various parameters.

III. METHOD AND MODEL

The finite element method using plaxis 2D software was used to study the behaviour of pile adjacent to deep excavation. Mainly four cases were considered for the analysis viz; without load on pile, with safe load on pile, excavation without support and excavation with support. Material properties for pile, side wall and soil considered for analysis are given in table 1 and table 2 respectively.

Table.1: Pile and side wall properties

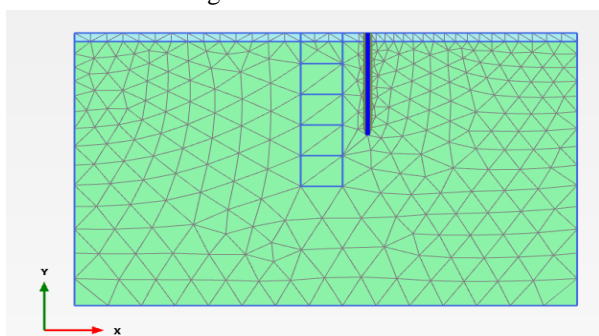
Parameter	Name	Layer 1	Layer 2
Material mode	Model	Mohr-Coulomb	Mohr-Coulomb
Unit weight above pheratic level (kN/m ³)	Yunsat	17.6	18.2
Unit weight below pheratic level (kN/m ³)	Ysat	19.39	20.05
Young,s modulus (Mpa)	E	7.5	10.5
Cohesion (kN/m ²)	Cref	20	35
Friction angle (degree)	Ø	17	17.5
Possion ratio	μ	0.1	0.15

Table.2: Soil Properties

Component	Density (kg/m ³)	Elastic modulus	Poisson's ratio
Pile	24	25	0.15
Wall	25	200	0.30

3.1 Model Preparation:

Model for analysis selected by performing number of analysis of different references for different size of model. Model selected for analysis gives maximum deflection value. The model consists of three parts; namely soil, pile and wall. Pile and walls are defined by plate element on model. Main features and dimensions of the finite element model is shown in Figure 1.



IV. RESULT AND DISCUSSIONS

For case 1 i.e. No support to excavation and no load on pile. A pile with 300 mm diameter in two layered soil was analyzed using PLAXIS 2D for varying depth of excavation to pile length ratio (H/L). The thickness of upper layer of soil walls $h_1 = 0.25L$. The maximum deflection observed is shown in Figure 2.

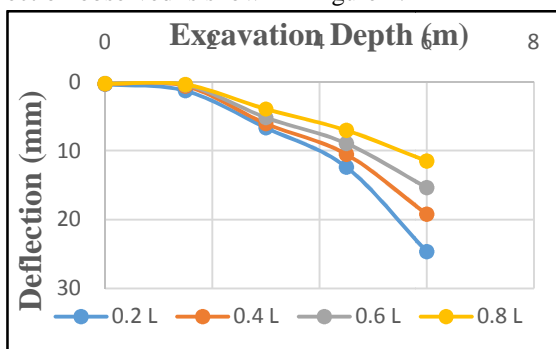


Fig.2: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for 0.25L.

Similarly for $h_1 = 0.5L$, $0.75L$ and L thickness of top soil, the pile deflections are as shown in figure 3 and 4 respectively.

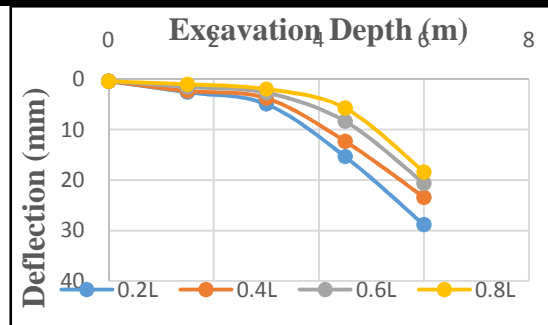


Fig.3: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = 0.5L$.

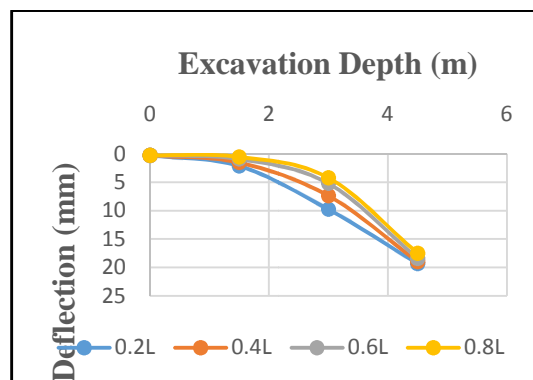


Fig.4: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = 0.75L$.

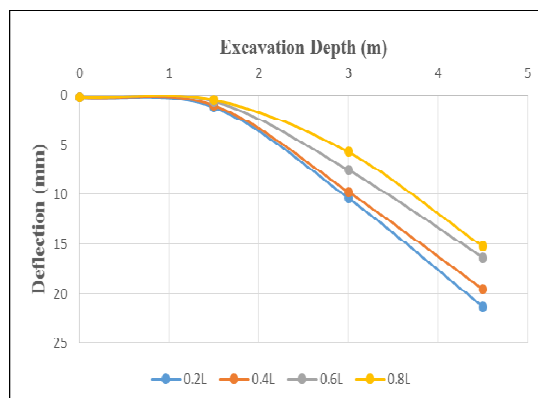


Fig.5: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = L$.

For case 2 i.e. No support to excavation and with safe load on pile. Figure 6 shows the deflection of pile for 5 m length of pile with $h_1 = 0.25L$.

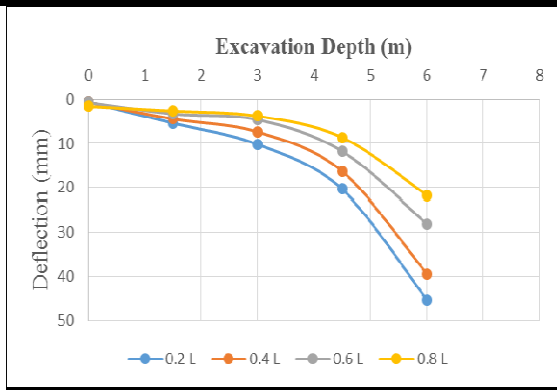


Fig.6: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for 0.25L.

Similarly for $h_1=0.5L$, $0.75L$ and L thickness of top week soli, the pile deflections: are as shown in figures 7,8 and 9 respectively.

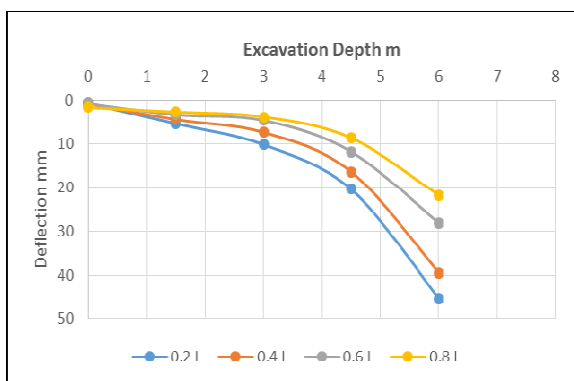


Fig.7: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1=0.5L$.

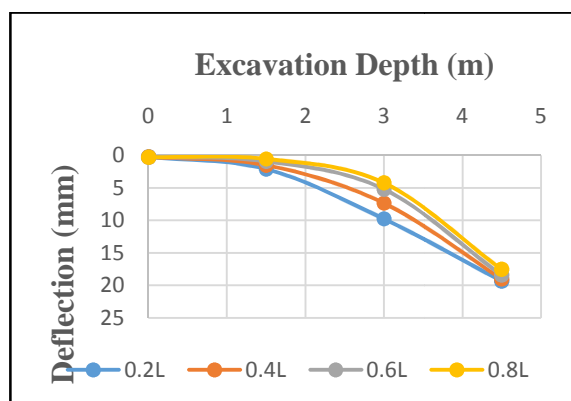


Fig.8: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1=0.75L$.

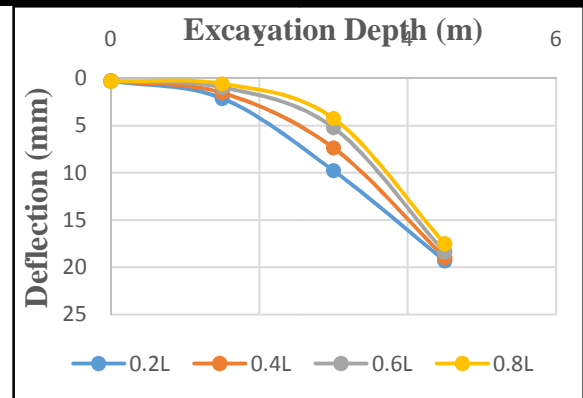


Fig.9: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for L .

For case 3 with support to excavation and no load on pile. Figure 10 shows the deflection of pile for 5 m length of pile with $h_1=0.25L$.

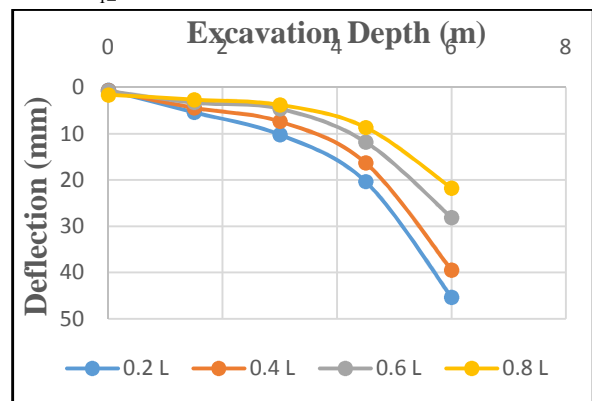


Fig.10: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1=0.25L$.

Similarly for $h_1=0.5L$, $0.75L$ and L thickness of top week soli, the pile deflections are as shown in figures 11,12 and 13 respectively.

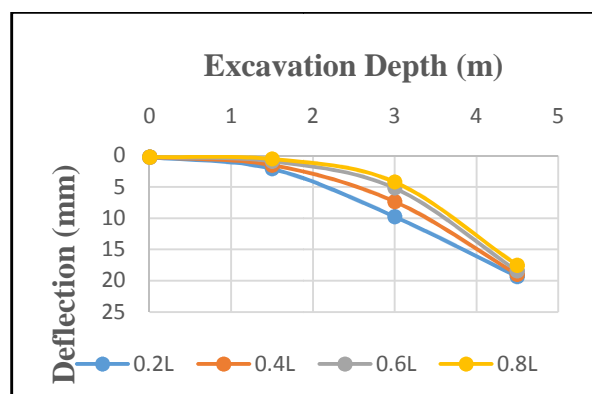


Fig.11: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1=0.5L$.

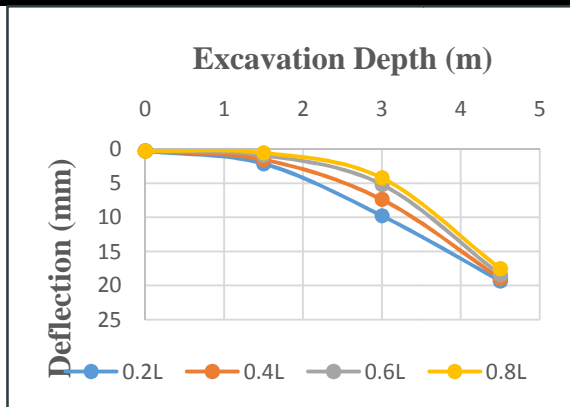


Fig.12: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = 0.75L$.

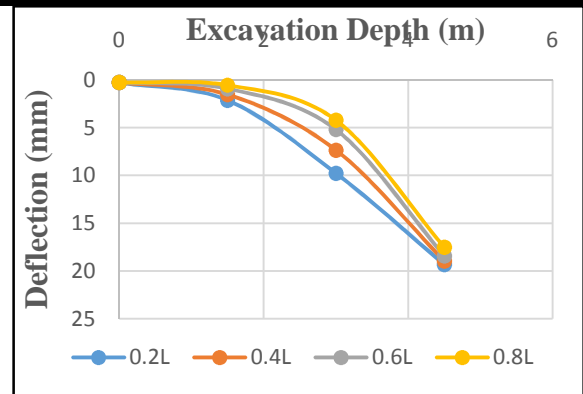


Fig.15: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = 0.5L$.

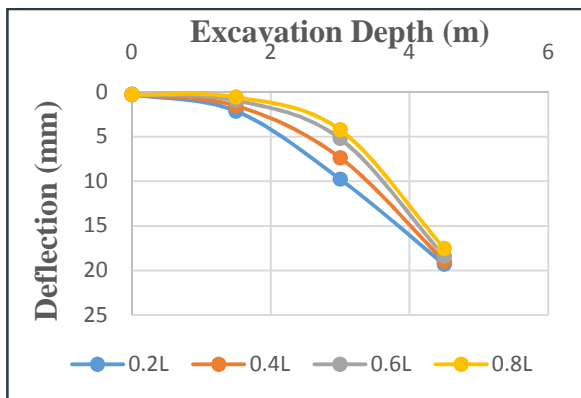


Fig.13: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = L$.

For case 4 with support to excavation and with safe load on pile. Figure 14 and 15 shows the deflection of pile for 5 m length of pile with $h_1 = 0.25L$ and $0.5L$ respectively.

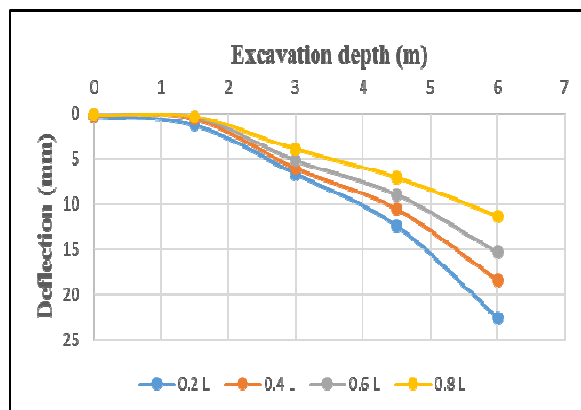


Fig.14: Deflection of pile (300mm) corresponding to excavation depth for 5 m length of pile for $h_1 = 0.25L$.

4.1 Discussion of results:

The results obtained for various cases and parameters of pile and soil are suitably discussed in following section.

4.1.1 Effect of diameter of pile on deflection of pile.

For no support and no load condition Deflection for various diameters were compared as discuss below.

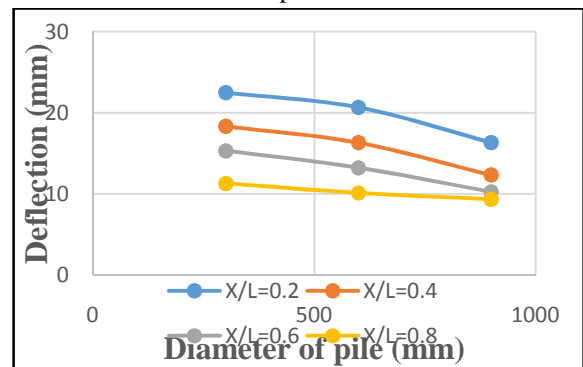


Fig.16: Effect of diameter of pile on deflection of pile.

Significant decrease in deflection of pile is observed with increase in diameter of pile in all cases.

4.1.2 Effect of length of pile on deflection of pile:

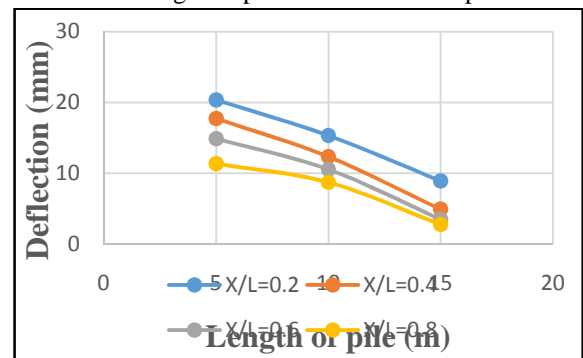


Fig.17: Effect of length of pile on deflection of pile.

Significant decrease in deflection of pile is observed with increase in length of pile in all cases.

4.1.3 Effect of distance of pile from excavation on deflection of pile.

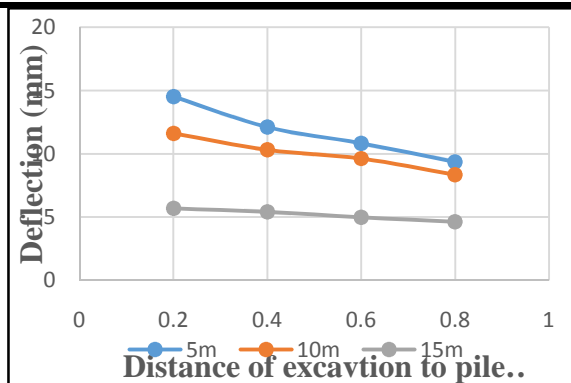


Fig.18: Effect of diameter of pile on deflection of pile.

Significant decrease in deflection was observed as distance of pile from deflection increases for 5m and 10 m. No markable decrease was observed 15m length of pile.

4.1.4 Effect of increasing top weak layer of soil on pile head deflection

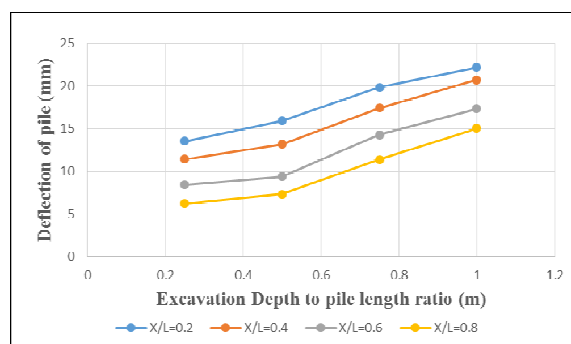


Fig.19: Effect of increasing the depth of top weak layer of soil on pile head deflection

V. COCLUSIONS

In the study undertaken, deflections of pile was evaluated for various cases and parameters. The broad conclusions drawn from the study are as follows:

1. As the distance of excavation from pile increases, deflection of pile decreases.
2. As the diameter of pile goes on increasing, decrease in pile head deflection was observed.
3. The depth of collapse of unsupported excavation can be decreased by insertion of pile because pile act as a reinforcing material.
4. As the length of pile increases, there is significant reduction in deflection of pile.
5. By providing support to excavation, remarkable reduction in deflection of pile is observed.
6. As the depth of excavation increases, deflection of pile also increases.
7. As the thickness of top layer of weak soil increases, deflection of pile also increases.

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